The Absorption of Occult Traditions into Early Modern Natural Philosophy: A New Account of the Decline of Magic*

[Original English version which appeared, translated into Russian, as: "Включение оккультных традиций в натурфилософию раннего Нового времени: новый подход к проблеме упадка магии", *Государство религия церковь в россии и за рубежом* (*State, Religion and Church in Russia and Worldwide*), New Series, 1 (2013), pp. 53-91 [ISSN 2073 – 7203 (print), 2073 – 7211 (online)].]

The Importance of Magic in the Origins of Modern Science

Isaac Newton's interest in alchemy is now well known, but attempts to deny that Newton could ever have been influenced by occult traditions are still a prominent feature of scholarly efforts to understand the man and his work.[1] A number of philosophers of science have recently insisted, for example, that Newton did not, indeed could not, believe that action at a distance was possible.[2] Whatever philosophers of science might wish to believe, however, the historical reality is perfectly clear. Newton took up the notion of action at a distance, an idea which had previously been excluded from natural philosophy but which flourished in occult traditions, and made it one of the corner stones of his physics (manifested most obviously in his concept of gravity, but also in the micro-matter theory discussed in the "Queries" appended to the *Opticks*).[3] Furthermore, due to his influence, the history of eighteenth-century natural philosophy, especially in Britain, can be seen in terms of those who accept the Newtonian claim that all phenomena can be explained in terms of attractive and repulsive forces operating at a distance (albeit microscopically small distances) between particles, or in terms of those who accept Newton's idea that all phenomena might be explained by a highly rarefied yet highly transmissive aether—an aether constituted of particles widely separated as a result of strong repulsive forces operating at a distance between the particles.[4] Newton almost single-handedly reversed the assumption (dominant since Aristotle) that "a thing cannot act where it is not", and made action at a distance a perfectly acceptable concept of physics. As John Stuart Mill wrote in his *System of Logic* of 1843," the ancient maxim that a thing cannot act where it is not… probably is not now believed by any educated person in Europe."[5]

It was only in the second half of the twentieth century that historians of science began to recognize the more magical aspects of Newton's work. The result of this on-going research is to acknowledge Newton as the "last of the magicians", the "last wonder child to whom the Magi could do sincere and appropriate homage".[6] There can be little doubt that he was the last, or among the last. By the time of Newton's death in 1727, the new reformed natural philosophy, which began to emerge in the sixteenth century and which had found its first programmatist in Francis Bacon, was sufficiently well established that its Enlightenment promoters saw it as *sui generis*, and felt no need to acknowledge its parentage. But Newton was by no means the only natural philosopher who had drawn upon magical traditions. Indeed, Newton's own interest in various magical traditions can best be understood by locating it within a late-Renaissance movement to reform natural philosophy by paying closer attention to various magical or occult traditions.[7]

Although it is now (at last) diminishing, there is still enormous resistance among the more positivist philosophers and historians of science to any suggestion that magic might have been instrumental in the emergence of modern science. It is remarkable,

for example, that the authors of two recent books on the role of alchemy in the Scientific Revolution, one introductory the other advanced, both felt the need to justify the claims they were making on behalf of alchemy because of its "associations with magic and the occult".[8] For the most part, the arguments against the possible influence of magic on science are presented *a priori*, while the historical evidence is simply ignored. So, magic is characterized as irrational and its influence upon a supremely rational pursuit like modern science is easily dismissed as inherently implausible. Similarly, magic is said to be concerned with the *supernatural* and therefore could only be antithetical to mankind's heroic intellectual endeavour to explain phenomena in entirely *naturalistic* terms.[9] What is particularly unfortunate about this approach is that, by dismissing magic at the outset, it fails to put any effort into understanding the nature and significance of magic in the pre-modern and early modern periods. But this ahistorical approach is intellectual chauvinism of the most arrogant kind, and the result is undoubtedly a diminishing of our understanding of the origins of modern science. To carry on in this vein is to repeat the errors of Sir David Brewster, Isaac Newton's first biographer. Taking the opportunity to scrutinize Newton's manuscript remains, Brewster soon came across the huge mass of alchemical manuscripts. His appalled response is well known:

> we cannot understand how a mind of such power, and so nobly occupied with the abstractions of geometry, and the study of the material world, could stoop to be even the copyist of the most contemptible alchemical poetry, and the annotator of a work, the obvious production of a fool and a knave.[10]

When seen in the light of Brewster's overwhelming admiration for Newton this is highly significant. An observer might have expected that Brewster would be led by his otherwise slavish veneration for his great forebear to conclude that, if Newton was so interested in alchemy, then there must have been something in it. But no, evidently Brewster's conviction that alchemy was worthless rubbish outweighed even his awe of Newton's genius. From a historically sensitive perspective, however, it should be assumed that if many of the leading figures in the Scientific Revolution (undoubtedly among the leading thinkers of their age) drew upon magical traditions it is our job as historians to try to recover what it was that they saw in those traditions. In the process, we will not only learn more about the nature of magic in the early modern period, but also about the origins of modern science.

Indeed, it seems perfectly clear that something recognizably like modern science first emerged as a direct result of the absorption of various aspects of the magical tradition into traditional contemplative natural philosophy. Both the experimental method, and the concern that knowledge of the natural world should be put to use for the benefit of mankind, can be seen to have been long-established aspects of the magical tradition which came increasingly to be embraced by students of nature, who thereby turned traditional natural philosophy into one or other of the so-called new philosophies of the early modern period. It hardly seems necessary to repeat the arguments in support of these claims about the methodology of the new science. This does not mean, however, that there is nothing more to be said. Even the substantive content of natural philosophy—not just its methodology—was expanded by absorbing beliefs from the magical tradition. It is evident that some aspects of the magical tradition were recognized by early modern thinkers as useful, and by implication, valid or true, while other aspects of the tradition were either ignored or rejected, and were by implication held to be invalid or false. The main aim of this article is to suggest that this was the general fate of the magical tradition. Some aspects of the tradition were taken up by practitioners and became absorbed into

reformed versions of natural philosophy, while other aspects of the tradition were rejected.

If it is true that major aspects of the magical tradition became absorbed into what we might call (if we are allowed a bit of anachronistic leeway) modern science, then this has implications for claims that have been made about a perceived decline of magic at the end of the seventeenth century. The 'decline' in question, of course, is the decline of magic as a topic for serious scholarly investigation and discussion. While magical ideas continued to flourish in popular culture, they declined dramatically among the highly educated elite, and came to be regarded as well beyond the intellectual pale. The reasons for this are undoubtedly manifold, and a number of reasons for the decline have already been discussed, most notably, of course, in Keith Thomas's *Religion and the Decline of Magic*.[11] The aim of this paper is to suggest another major reason for the decline of magic; a reason which has not been discussed before, and which has significant implications for our understanding of early modern intellectual history.

In the rest of this paper, therefore, I want to offer a new perspective to add to previous attempts to explain the so-called decline of magic. I suggest that a number of features of what were regarded as occult arts and sciences during the Renaissance and early modern periods, came to be appropriated by natural philosophers and so became absorbed into the new philosophies. To a large extent it was the in-put from magic that made the new innovatory philosophies what they were, not only with regard to the experimental method and the new ethos that natural knowledge should be pragmatically useful, but also with regard to their substantive content. At the same time, however, other aspects of the magical tradition were firmly rejected. These historical changes are perhaps best understood in terms of what sociologists of science have called 'boundary work', the process of demarcating supposed legitimate and valid procedures and presuppositions in establishing natural knowledge from those that are deemed invalid and illegitimate. [12] From the Renaissance through the period known as the Scientific Revolution there was a complete rearrangement of the boundaries of what was magic or occult and what was not, which in turn involved a redrawing of the boundaries which determined what was natural philosophy and what was not. Furthermore, it is my contention that this led to a decline in the fortunes (among orthodox thinkers at least) of what was left behind in the realms of magic.

My account also helps us to see, therefore, what is in fact a major historical and historiographical irony. The reason why positivistically-inclined commentators on the development of science have refused to acknowledge the relevance of magic to the history of science is because they mistake the rejected left-overs of the magical tradition—the pathetic rump of the tradition remaining after early modern natural philosophers had taken what they wanted from it—as the whole of the tradition. I said earlier that such historians, like Brewster confronted with Newton's alchemy, refuse to make any attempt to understand the nature of the magical traditions. Just as Brewster, writing in the 1850s, knew the current reputation of alchemy and didn't try to assess its reputation in Newton's day, so certain modern commentators of science have relied upon their current understanding of what magic is (and by implication always has been), and have refused to accept the claims of other historians that magic was once so different that, properly understood, it is easy to see how it might have, and indeed did, influence the development of modern science. The currently prevailing conception of the magical tradition began to be forged in the eighteenth century and has continued into our own times.[13]

The Nature of 'Magic'

One major reason for the prevailing mistaken conception (by positivist historians and others) of the nature of magic in the Renaissance is the lack of any understanding of what was known as *natural* magic. Lack of awareness of the natural magic tradition is due to the fact that it was to a large extent completely absorbed into what we now think of as science, while other, lesser, aspects of the tradition have remained in what should be regarded as merely a rump of the magical tradition—what was left over after parts of the tradition had been absorbed into natural philosophy. Today, we tend to identify magic with the supernatural (if we leave aside the stage trickery of 'show-business' magic), but in the period we are looking at, to describe an event or a phenomenon as supernatural was to say that it had been brought about miraculously by God—only God was above nature, and only God could perform a *supernatural* act.[14] Magic, by contrast, exploited the *natural* properties of things and the successful magician was believed to be highly knowledgeable about the different occult qualities of things. As Giovanni Battista Della Porta wrote:

> Magic is nothing else but the knowledge of the whole course of Nature... This Art, I say, is full of much vertue, of many secret mysteries; it openeth unto us the properties and qualities of hidden things, and the knowledge of the whole course of Nature; and it teacheth us by the agreement and the disagreement of things, either so to sunder them, or else to lay them so together by the mutual and fit applying of one thing to another, as thereby we do strange works, such as the vulgar sort call miracles... Wherefore, as many of you as come to behold Magick, must be persuaded that the works of Magick are nothing else but the works of Nature, whose dutiful hand-maid magick is.[15]

This definition appears in the most popular textbook of magic of its day, simply titled *Magia naturalis*, but the same claims about the nature of magic are repeated time and again. Cornelius Agrippa, a leading Renaissance contributor to the magical tradition, insisted that "magicians are careful explorers of nature only directing what nature has formerly prepared, uniting actives to passives and often succeeding in anticipating results so that these things are popularly held to be miracles when they are really no more than anticipations of natural operations".[16]

The major assumption of natural magic, then, was that all bodies have occult qualities which make them capable of acting upon other bodies in various ways, though in many cases the working of these occult qualities are supposed to be highly specific. The main method of putting magical knowledge to use, therefore, is to bring together a body known to have a specific action and the body upon which it is known to act, or else to separate such reactants for a negative effect. This is what Della Porta meant by sundering or laying together things in accordance with their "agreement and disagreement", and what Agrippa meant by "uniting actives to passives". This doctrine made a major impression on the great reformer of natural philosophy, Francis Bacon, who stated it in the fourth Aphorism of his influential *New Organon*: "Towards the effecting of works, all that man can do is put together or part asunder natural bodies. The rest is done by nature working within."[17] Such occult interactions were often described in terms of sympathies and antipathies between bodies, a notoriously magical way of talking which nevertheless was employed with minor changes by such leading exponents of the new philosophy as Robert Hooke, who spoke of congruities and incongruities between bodies, and Isaac Newton, who explained certain chemical phenomena in terms of principles of sociability and unsociability.[18]

When compared with natural magic other aspects of the tradition, aspects which today are all too often held to be characterizing features of magic, were distinctly subordinate. The truly learned magus was held to be a man with a vast knowledge of "how to effect things worthy of the highest admiration... by the mutual application of natural actives and passives".[19] The great magician, in other words, knew by experience many of the operations of the occult qualities of things and knew how to put that knowledge to use. Lesser magicians, however, might have to resort to one or other of two alternative aspects of the tradition, as a substitute for their lack of knowledge. Both of these aspects of the magical tradition were seen as means of cutting corners, or of taking a short cut, to the knowledge of the occult qualities which the real magus would learn by experience (in principle at least—though in practice more usually by relying on magical lore, increasingly *printed* magical lore). [20]

I am referring here to sorcery (which includes necromancy, theurgy, witchcraft and all other arts of summoning spiritual beings), and semeiology or symbolic magic (which relies upon the power of signs, words and other symbols, and includes numerology, gematria, spellbinding, incantation and so on). These are the very things which many think of today as definitive of magic, but this is largely thanks to the re-drawing of boundaries which took place in the early modern period. In the pre-modern period sorcery and symbolic magic were seen primarily as *subordinate* to natural magic. An important element of symbolic magic, for example, involved the reading of the 'signatures' of things. It was supposed that God, at the Creation, had left physical clues about the secret workings of things, these were the signatures. So, as one commentator wrote: "besides the manifest and occult qualities of plants, from which their uses may be inferred, [Nature] has marked those which are most useful to us with certain signs and characters".[21] God and Nature, after all, did nothing in vain, and so there must be a reason for every characteristic feature that a thing might have. A favourite example among historians is the walnut: crack open the shell and the flesh of the walnut can be seen to resemble the human brain sitting in the skull, being divided down the middle and having a surface made up of convolutions. What else could this be but a sign from God that the walnut bears some relationship to the human head or brain? The usual assumption was that the signature indicated some curative power, and so walnuts were assumed to offer a cure, perhaps for headaches, or for mental disturbance. Needless to say, precise determination of the efficacy of walnuts would require empirical research of a trial and error kind. In this respect at least, then, knowledge of symbolic magic, or an ability to read the signatures of things, can be seen as a short-cut to the knowledge of occult qualities required by the natural magician.[22]

The link between natural magic and the signatures of things is easy to see, but to link *sorcery* to natural magic seems, on the face of it, bizarre in the extreme. Surprising though it may seem, however, sorcery too was seen as little more than a way of avoiding the painstaking gathering of knowledge of occult qualities from experience. If we wish to understand this we must once again be aware of the shift in meaning of the notion of the 'supernatural'. From our perspective it seems a reasonable assumption that for pre-modern thinkers demons were capable of performing supernatural acts to bring about some miraculous event. This fits *our* assumptions about demons. *Our assumptions, however, are historically misguided*. It is something of an irony that present-day notions of demons with comic-book superpowers are the products of *secular* imaginations. In the pre-modern and early modern intellectual cosmology only God could do supernatural things. Demons, even the Devil himself, were God's creatures and as such were subject to natural law just

like the rest of us.[23] As John Cotta wrote in *The triall of witch-craft* (1616): "Nature is nothing else but the ordinary power of God in all things created, among which the Divell being a creature, is contained, and therefore subject to that universal power".[24] In so far as the Devil *could* perform marvelous feats it was only by virtue of the fact that he was a consummate natural magician. The Devil knew the occult qualities of things, and how to apply appropriate actives to passives to accomplish whatever might be required. William Perkins put it rather well in his *Discourse of the damned art of witch-craft* (1618):

> [The Devil has] exquisite knowledge of all natural things, as of the influences of the starres, the constitutions of men and other creatures, the kinds, vertues, and operation of plantes, rootes, hearbes, stones etc., which knowledge of his goeth many degrees beyond the skill of all men, yea even those that are most excellent in this kind, as Philosophers and Physicians are.[25]

Accordingly, if a would-be practitioner of natural magic was at a loss about how to accomplish a particular outcome he might decide to summon a demon, or even the Devil himself. It is important to note, however, that if the Devil did succeed in performing what the magus wanted it would be because, as William Perkins wrote:

> in nature there be some properties, causes, and effects... most familiar unto him [the Devil], because in themselves they be no wonders, but only mysteries and secrets, the vertue and effect whereof he hath sometime observed since his creation.[26]

The Devil, in other words, does these things in the same way that the natural magician does, but with greater success because of his greater experience—the Devil, after all, has been around for a very long time. The vulgar might think that the Devil and the magus are capable of producing miracles, but, as Cornelius Agrippa insisted, both merely anticipate and exploit natural operations.[27] "Demons operate nothing", wrote Francesco Giuntini, "except by natural application of active forces to the appropriate and proportionate passive objects, which is the work of nature."[28] The Devil has no supernatural power, he accomplishes his ends by exploiting the occult powers of nature.

So, although the logic of symbolic magic and the logic of demonology were closely linked to the logic of natural magic in the pre-modern period, by the end of the sixteenth century a re-alignment was under way. By the end of the seventeenth century major aspects of the natural magic tradition had been appropriated by the new philosophies or redefined in order to fit more easily with the new kinds of naturalism. But Symbolic magic, demonology and some aspects of natural magic, such as astrology, and the chrysopoeic aspects of alchemy, were left aside in what was effectively a new, differently defined, category of magic. This new category was now seen by the learned as merely bogus and invalid knowledge—as indeed it was, because the useful aspects, such as the notion that forces could operate at a distance, had all been absorbed into mainstream natural philosophy.

An important aspect of the re-designation of natural magic as a set of assumptions that could be more fruitfully exploited in natural philosophy was, effectively, a denial that natural magic was magic. Thanks principally to the power of the Church, magic had always had what today would be called a 'bad press'. As if the escapades of frauds and charlatans claiming to be alchemists, astrologers, and magicians were not enough to damage the reputation of magic, the Roman Catholic Church tended to emphasize its demonological aspects in order to present it as dangerous and irreligious. It seems clear that the Church wanted to avoid confusion between the miraculous and the kind

of marvellous things which were achievable through natural though occult means. Natural magic seemed to suggest, to the uneducated at least, that miraculous things could be accomplished by laymen without supernatural aid. This implicit threat to the authority of the Church could be neatly turned around by insisting that all magic was accomplished by demonic aid, and so condemning it in the most vigorous terms. For the Church, every magus was a Doctor Faustus (and during the witch-crazes every village 'cunning man' or more especially 'cunning woman' was accused of deriving their knowledge not from natural lore but directly from Satan).[29]

It is hardly surprising, therefore, that although we come across many reputed magicians in the historical record, we do not come across many who declare *themselves* to be magicians; on the contrary, they usually deny it. Nobody was reputed a greater magician than Roger Bacon and yet Bacon himself vigorously denied that he did anything by magic. If we were to take Bacon, and other magicians in denial, at their word, however, we might have to conclude that there was no such thing as a magical tradition, and that nobody ever was a magician. In a sense the latter is true, because there never was a Merlin, or a Faust, there were only mathematicians, alchemists, cabbalists, natural philosophers of a more mystical bent than usual, humanist scholars enthralled by Neoplatonic theurgy, and so forth.[30] But we need to bear in mind the historical actors' categories, not our own. From the point of view of his contemporaries, Roger Bacon was, as George Molland has pointed out, "a full-blooded magician", and in Molland's estimation this was hardly surprising since, in spite of his protestations to the contrary, Bacon "went some way to meriting his later classification as a magician".[31]

As a result of religious condemnation of magic, then, it wasn't possible simply to appropriate occult traditions in an open way into natural philosophy. Accordingly, an important aspect of the absorption of natural magic into reformed versions of natural philosophy was the defense of those past thinkers who were alleged to be magicians from all charges that they were magicians. Again, as George Molland has pointed out, reputed medieval magicians like Al-Kindi, Albertus Magnus, Roger Bacon, Arnald of Villanova and Michael Scot were transformed in early modern scholarly literature from magicians into heroes of experimental science. The major contribution to this new enterprise was Gabriel Naudé's *Apologie pour tous les Grands Personages qui ont esté faussement soupçonnez de Magie* (Paris, 1625), but John Dee, evidently defended Roger Bacon, in a work now lost, from charges of sorcery.[32] Similarly, Robert Hooke later took it upon himself to defend Dee. Having acquired increased notoriety from a newly published account of his supposed converse with various angels, Dee was defended by Hooke as a cryptographer rather than a sorcerer. According to Hooke, these angelic conversations were in fact a "concealed History of Nature and Art". In taking this line, Hooke was simply re-using the same defense which had been used to protect the reputation of Johannes Trithemius—another magus who reported his conversations with angels, but which were later claimed to be merely exercises in cryptography (the point of the exercises being to find what was really being said under the guise of these conversations with angels).[33]

Other exploiters of the magical tradition chose to obscure their indebtedness to the tradition, or to confuse contemporaries as to their commitment to magic. Francis Bacon vigorously criticized magic even as he appropriated many of its precepts and doctrines.[34] Cornelius Agrippa made the status of his *De occulta philosophia* (Cologne, 1533) somewhat ambiguous by publishing what looked like a retraction of it three years before publishing the work itself (although the supposed retraction, *De*

incertitudine et vanitate scientiarum, has recently been shown to be far from straightforward).[35]

Neither silence about magical influence, nor even explicit denial of magic, should be taken as evidence that magical traditions did not play a role in the origins of modern science. Early modern thinkers re-constituted symbolic magic as beyond the intellectual pale, for example, while continuing to accept natural magic; others reasserted the untenability of sorcery (whether on sceptical or religious grounds[36]), while claiming other facets of the magical tradition as defining aspects of natural philosophy. Those positivistic historians and philosophers of science who have regarded magic as antithetical to science have made the mistake of neglecting such changes in what constituted magic. They have tended to assume that magic in the early modern period was essentially the same as what it became after the Enlightenment. In fact, the category of magic has changed radically. Chiefly because significant parts of the original tradition have been absorbed into natural philosophy, and redefined by the historical actors themselves (all too conscious of religious opposition to magic) as though they were always aspects of natural philosophy or other legitimate attempts to understand the natural world.[37] I disagree, therefore, with the suggestion of Frank L. Borchardt that, sooner or later, magicians themselves expressed a "disappointment in magic", recognising that it led inexorably to demonolatry, and repudiated it as they all turned back to religious orthodoxy. It seems to me that the story is rather one of negotiating with the faith, their own as much as that of leading Churchmen, and appropriating certain aspects of magic into their own philosophical systems, while leaving the more religiously dangerous aspects to remain in what became an increasingly demonologically defined (as opposed to the former more *naturally* defined) magic.[38] One of the major reasons why the influence of magic on science (if we can speak anachronistically for the sake of a historiographical argument) has been denied is precisely because those aspects of magic which clearly did influence science are now simply regarded as part of the history of science, and so no longer recognized to be part of the history of magic. Meanwhile, those aspects of magic which were not absorbed into science, and to a large extent were seen in the early modern period as antithetical to a proper understanding of natural phenomena, have come to be regarded as entirely representative of magic, not just as it was after the end of the seventeenth century, but as it was throughout the whole of its career through Western culture. This is simply a very misleading mistake.

The Selective Absorption of Aspects of the Magical Tradition

The foregoing should not be taken to mean that natural philosophers simply decided in a deliberate way to look into the magical tradition to see if there was anything they could incorporate into their natural philosophies. This was no more the case than that natural philosophers in the sixteenth century deliberately decided to go and see what artisans and craftsmen were doing, on the chance there might be something they could use. Nevertheless, it is just as true to say that natural philosophers began to become more and more familiar with occult arts and sciences as it is to say that scholars and craftsmen began to interact during the Renaissance as they never had before.[39] In some cases, of course, reformers did extol the deliberate appropriation of knowledge from craft or magical traditions, and no doubt some of their readers did follow suit. Certainly, Juan Luis Vives did urge his scholarly readers in 1531 "to enter into shops and factories, and to ask questions from craftsmen, and to get to know about the details of their work"; and Francis Bacon urged readers of his *Novum organum* (1620) to systematically search through magical lore,

> for although such things lie buried deep beneath a mass of falsehood and fable, yet they should be looked into… for it may be that in some of them natural operations lie at the bottom; as in fascination, strengthening of the imagination, sympathy of things at a distance, transmission of impressions from spirit to spirit no less than from body to body and the like.[40]

For the most part, however, what we are dealing with is a diffuse movement, throughout Europe and spread over the sixteenth and seventeenth centuries, of thinkers adopting, or adapting, theories, assumptions, and techniques which previously would have been seen as too occult or too susceptible to the charge of being demonic, into what came to be accepted as the new philosophy. Again, different aspects of this diffuse movement, need to be understood differently. William Gilbert, who developed an explanation of the perpetual movement of the Earth (demanded by Copernican theory) based on the occult properties of magnets, may not have been looking for a way to explain the motion of the Earth, but realized he could offer an explanation after reading Pierre de Maricourt's *Epistle on the Magnet*. Robert Boyle did not turn to alchemy as a result of his dissatisfaction with Cartesian mechanical philosophy—he already was an alchemist, and may well have recognized inadequacies in Cartesianism precisely because of his alchemical knowledge.[41] In lots of different ways magical ideas became incorporated into the mainstream of philosophical thought, but only in a few cases was this the result of a self-conscious effort to plunder magical traditions.

The precise way in which different areas of the occult arts and sciences were taken up by natural philosophers can be seen, therefore, to be complex and affected by many historical contingencies. It is not possible to provide a model which reveals how the occult was absorbed into mainstream philosophy because each case was very different. The process was not systematic, and may not even have been fully comprehensive, embracing every aspect of the occult, but it was undeniably extensive. What follows in this section is not intended to be a complete account, but merely a preliminary attempt to show how aspects of at least some of the occult sciences came to be incorporated into the new philosophies of the early modern period, while others were considered for inclusion but ultimately rejected.

So-called mathematical magic, for example, was concerned with the demonstration of what could be accomplished by machinery. Machines, after all, were intended to perform marvellous feats which could not be done by normal means, and they did so in ways that were by no means manifest to a casual observer. Their operations were, therefore, by definition *occult*. In part this can be seen as an example of Arthur C. Clarke's 'law', that "any sufficiently advanced technology is indistinguishable from magic". But it would be a mistake to assume that this meant that Renaissance thinkers believed that machinery was worked by hidden demons.[42] The ill-educated were superstitious, of course, and sometimes might well have thought this way, but among the educated it was perfectly well known that machines worked by means of cunningly arranged mechanical contrivances. Consider, for example, Salluste du Bartas's description of the "iron fly", allegedly built by the mathematician Regiomontanus and capable of flying around a room:

> O devine wit, that in the narrow wombe
> Of a small Flie, could finde sufficient roome
> For all those springs, wheels, counterpoise, & chaines,
> Which stood in stead of life, and spurre, and raines.[43]

This iron fly would still have been held to work by occult means. Because the mechanical arrangements which "stood in stead of life" were hidden, and their mode

of operation was not obvious to the senses, and moreover could not be explained in the terms of Aristotelian natural philosophy, they were regarded as occult powers, analogous to the workings of occult qualities in natural bodies.[44]

The mathematisation of the world picture has always been regarded as an important element in the Scientific Revolution, but scholarly analysis of this crucial historical process has failed to pay sufficient attention to the undeniable associations between mathematics and magic in the Renaissance. Historians of mathematics have looked to humanists, astronomers, Jesuit mathematicians, and mathematical practitioners of the more pragmatic kind (artillerymen, surveyors, merchant book-keepers, and engineers of various kinds), but have largely ignored those Renaissance intellectuals who were more concerned with the magic of mathematics.[45] This is undoubtedly another result of the positivist tendencies among historians of science, tending to dismiss anything which smacks of magic. Where magical mathematics has been discussed it has been seen purely as an aspect of Renaissance culture, and its possible relevance to the subsequent development of mathematics is left unconsidered. J. Peter Zetterberg, for example, takes it for granted that there was something called 'the mathematicks' which was unfortunately all too often *mistaken* for magic. It evidently never occurred to him that mathematics could have been, as indeed it was, regarded by pre-modern thinkers as a major part of the magical tradition.[46] As far as most pre-modern thinkers were concerned, to describe a man as a mathematician was to describe him as a wizard; this was certainly true, for example, in the cases of John Napier and John Dee.[47]

By the time John Wilkins, one of the major contributors to the new philosophy in England, came to publish his *Mathematical magick* (1648), he felt it necessary to apologize for the title. By now, educated men were getting used to the idea that mathematics had an important place in natural philosophy (something which had always been denied by Aristotle), and mechanics was increasingly being seen as a science which depended upon natural phenomena, and so the workings of machinery could be seen as part of natural philosophy, and could shake off its old association with magic.[48] The process of incorporating mechanics into natural philosophy began with the Renaissance discovery of the *Mechanical questions*, attributed (wrongly) to Aristotle and first translated into Latin by Vittore Fausto in 1517. It required the re-casting of mechanics from an art to one of the mixed mathematical sciences, before Descartes could insist, in 1644, that "there really are no reasonings in Mechanics which do not also pertain to Physics, of which it is a part or species."[49] Although historians of mathematics have tended to be even less interested in assessing the possible influence of occultism than historians of science have been, there seems to be a *prima facie* case for assuming that changing attitudes to mathematics, and changes in the intellectual status of mathematics, owed something to the reassessment of occult traditions which took place during the Renaissance.

The entirely undeniable role of alchemy in the development of modern science also needs to be understood in a carefully nuanced way. In an important article Lawrence Principe and William Newman have recently shown that our modern view of the nature of alchemy is severely distorted by various reconstructions of it which derive from nineteenth-century occultist movements, and have no real historical basis in the alchemy of the pre-modern period.[50] The historiographical rot set in when Enlightenment thinkers drew a spurious distinction between chemistry, in something like the modern sense, and alchemy, which was presented as being concerned solely with transmutation of base metal into gold.[51] This in itself can be seen as part of the trend, still active in the eighteenth century, to separate the new natural philosophy

from magic. The need for this kind of separation of alchemy from chemistry became even more urgent for later spokesmen on science because of the appropriation of alchemy by various nineteenth-century occultists.[52] Newman and Principe are in the forefront of on-going efforts to recover the real history of alchemy from these obfuscations, and to show precisely how alchemy was absorbed into modern science, and what was left out (or, in this case, what came to be interpolated subsequently into a bogus history of alchemy invented by later occultists). In connection with this, Principe and Newman point out that not all alchemists subscribed to an animist, or even a vitalist, view of matter, and that such differences might have resulted in a different kind of take-up of alchemical ideas by reforming natural philosophers. Similarly, they point to recent work which has shown that alchemical matter theory was often corpuscularian, and even mechanistic, and which certainly played a part in the new matter theories of the Scientific Revolution.[53]

If alchemy was broken down into a general concern with chemical interactions and processes on the one hand and a concern with metallic transmutation on the other, and only the former made it into the new science, we can see a similar process with regard to the absorption of herbalism and the lore of Medieval bestiaries. Studies of flora and fauna in the pre-modern period were overlaid with assumptions about the religious, moral and symbolic significance of all God's creatures, as well as their potential for providing *materia medica*. Many of these assumptions, in what historians have referred to as the "emblematic worldview", derived from the belief in correspondences within the Great Chain of Being, and included various occult associations, based upon what were considered to be God-given signatures. As botany and zoology came to be included in the new science, however, much of this magical and mythological lore, once considered to provide essential information about the plant or animal in question, was excluded.

To understand this change in attitude about knowledge of natural things, we need to consider the effect of the discovery of the new world. Plants and animals from the new world came to the West devoid of any symbolic associations—they had no religious or moral significance deriving from either historical and religious legends, or from humbler folklore. Naturalists had no choice but to confine themselves to known facts about this new flora and fauna. In subsequent compendiums of natural history, therefore, there was a clear shift towards treating *all* plants and animals in the same strictly descriptive way. Just as creatures unknown to European culture had to be recorded merely in terms of what could actually be observed, so the old folkloric associations were stripped away from familiar plants and animals. To a large extent this resulted in a less magical world picture, but it would be wrong to see this as a steady triumph of science over magic.[54]

Belief in the occult qualities of those plants and animals used in *materia medica*, supposedly based upon past experience anyway, was not affected by this increased emphasis upon observation. Furthermore, the tendency of explorers was to bring back just those plants which were deemed by native populations to be most useful in curing disease. More often than not, European doctors could not decide how, or even whether, such unknown drugs worked on the four humours of the body. Without so much as an *obiter dictum* from Aristotle, or Dioscorides, or some other ancient authority, it was often impossible to tell whether a plant worked through heat, cold or one of the other manifest qualities. Increasingly, therefore, medical thinkers declared new drugs to work by means of the major alternative to the manifest qualities: occult qualities. This even led to a re-working of medical and therapeutic theory, in which some diseases were held to be the result not of an imbalance in the

humoral constitution, but a corruption of the whole substance of the body. The only drugs capable of curing these diseases were those that operated, likewise, on the 'total substance' of the body, not merely on a particular humor.[55] The *occult* qualities of *materia medica*, as opposed to supposed manifest qualities of heat, cold, moistness and dryness, were increasingly recognized and accepted into the new natural philosophy.

I believe it would be possible to continue in this vein, showing how different aspects of the magical tradition were partially taken up by natural philosophers, while other aspects were entirely excluded. In all cases, as with the examples briefly discussed here, the story will be one where the historical complexities derive from a host of contingencies. It is fairly obvious, for example, that the precise way in which alchemy, or part of it, became absorbed into natural philosophy was different from the way that so-called 'mathematical magic'—the use of machinery to improve human faculties—was adopted.[56] Furthermore, some prominent aspects of the natural magic tradition, such as a belief in the natural power of words, were not included within the new boundaries at all. In other cases, aspects of the tradition were only taken up in a very restricted sense, as in the case of numerology, which seems to have led Kepler and Newton, to cite two prominent examples, to draw specific conclusions about the natural world, but can hardly be said to have been a general influence.[57] If we bear in mind, also, that the magical tradition was undoubtedly a major source for the experimentalism of the new philosophies, and for the idea that knowledge of the natural world should be useful for the benefit of mankind, it seems hard to deny the claim that the new philosophies were greatly indebted to the magical tradition.[58]

Why the Change?

The question arises, therefore, as to why this sea-change occurred. Why was the map of knowledge redrawn between the end of the Renaissance and the beginning of the Enlightenment? Why were the boundaries redefined so that natural magic lost its identity by becoming largely absorbed into the new 'natural philosophy' (which now, thanks to the experimental method, the integral use of mathematics, and the concern with pragmatism was closer to our modern concept of science than it was to the earlier tradition of contemplative natural philosophy), while symbolic magic came to be seen, by the educated at least, as superstitious nonsense,[59] and demonology, formerly a borderline category linking religion and natural philosophy, became first of all an entirely religious category, and with increasing secularization was thoroughly rejected?[60]

As with so many other problems in history, the answers to this question are no doubt legion. We have already considered a few reasons along the way, such as the change in status of mathematics, helped by the discovery of the supposedly Aristotelian *Quaestiones mechanicae*, but it is beyond the scope of this article to survey all the other possible factors. It is clear, for example, that the full story could not be told without paying careful attention to the social and political context of Renaissance and Reformation Europe, and how developments in these spheres affected intellectual life.[61] What I want to do here is simply to consider briefly some of the more immediate reasons why the boundaries of magic and natural philosophy were redrawn in just the way they were. By 'immediate' I mean those reasons which arose directly out of the efforts of Renaissance and early modern thinkers to improve their understanding of the natural world.

Perhaps the first thing to mention in this connection was the change in the intellectual status of magic as a result of the discovery of the essentially religious writings attributed to Hermes Trismegistus. Thanks to a generally accepted belief in the wisdom of Adam, it was usually assumed in the pre-modern period that knowledge was something that needed to be recovered from the past. Adam knew all things, but thanks to the Fall, this wisdom had been successively forgotten. For the pre-moderns, therefore, thinkers of great antiquity were more likely to know more—to have forgotten less of the Adamic wisdom—than a contemporary thinker. This belief is most familiar to historians of science through the common designation of the Copernican theory as the Pythagorean theory.[62] The Copernicans knew that if they were to have any chance of persuading their contemporaries of the truth of the Copernican theory they had to show that it had been believed in the past. The ancient sage, Hermes Trismegistus, was regarded as a contemporary of Moses, and he was seen to be responsible for transmitting the Adamic wisdom to the pagan Greeks, as Moses had transmitted it to the Jews. This belief was easy to sustain in the light of the fact that the newly discovered Hermetic writings showed clear foreshadowings of Christian belief, including its trinitarianism. As we now know, these supposed foreshadowings were in fact echoes of Christian belief, since these writings were actually compiled by Neoplatonists in the early centuries of the Christian era.

The first translator of the Hermetic Corpus (a substantial part of it, at least) was Marsilio Ficino who was clearly fascinated by Neoplatonic theurgical beliefs and who began to develop his own theory of what D. P. Walker called 'spiritual magic' in his *De vita coelitus comparanda* (1489). Ficino's work proved immensely influential and helped to promote the view that Hermes Trismegistus was above all else a magician. [63] This identification of Hermes as a magus was helped by the fact that, as well as the Neoplatonic theistic writings attributed to him, there were also a considerable number of astrological, alchemical and natural magical texts also attributed to this great sage. Given the belief in Adamic wisdom, and the belief in the great antiquity of the Hermetic writings, magic came to be seen as one of the oldest forms of knowledge, and was therefore newly invested with great respectability. After centuries of being disparaged by the Church, magic came to be seen as a major aspect of Adamic wisdom. Accordingly, as Eugenio Garin has suggested, there was a brief time, shortly after the discovery of the Hermetic Corpus, when it was acceptable to be called a magus, and to acknowledge oneself to be a magus (remember, we have already seen that it was much more usual to deny that one was a magician).[64] It is hardly surprising therefore that reforming natural philosophers of the Renaissance and early modern periods should look with fresh eyes at the magical tradition, and consider more seriously than before what it had to offer.[65]

Another reason why the boundaries of magic came to be redrawn arose from rapid developments in the understanding of earlier magical traditions as a result of the humanist scholarship of the Renaissance. In particular, the recovery of the works of Ancient Neoplatonists, such as Plotinus, Proclus, Iamblichus and others, revealed a theory of magic in which "spiritual and demonic magic" played a greater role than natural magic. This alternative to the Aristotelian tradition first became known as a result of the work of the famous Florentine philosopher and translator, Marsilio Ficino, whose *De vita coelitus comparanda* of 1489 was a full exposition of the theory of magic which drew not only upon Aristotelian traditions of occult qualities but also upon the more theurgical theorising of the later Neoplatonists. Although Ficino himself seems to have managed to stay within the confines of natural magic as it was traditionally conceived (with the emphasis on the *natural*), his exposition drew

attention to the fact that later Neoplatonists seemed to believe that occult qualities in matter were clear signs of divine or demonic presence within the matter. For the pagan Neoplatonists, in other words, the occult but *natural* effects discussed in traditional natural magic were, in fact, *supernatural* effects brought about directly by gods or demons. Although such ideas were pagan and could easily be shown not to fit in with Christian Aristotelianism, they ensured that the boundary demarcation between natural and supernatural and the abilities of demons were placed firmly on the agenda of scholarly discussions. In this way, occult qualities, formerly hardly discussed within the scholastic tradition, became important items for discussion.[66]

One of the most important of such discussions was that of the notorious secular Aristotelian philosopher, Pietro Pomponazzi. Pomponazzi was, as Brian Copenhaver has recently said, "entirely and aggressively naturalist" and in 1520 he wrote a treatise *On the causes of marvelous natural effects and on spells*, in which he explicitly intended to make demons redundant for any understanding of the natural world. One of his arguments was that, even if demons were capable of knowing better than men all the occult qualities of things and how to accomplish things by bringing together sympathetic actives and passives, because demons were spiritual, incorporeal, beings they were completely incapable of manipulating matter to accomplish anything by their knowledge.[67] Once again, Pomponazzi's book, like Ficino's, stimulated debate about occult qualities, demons, and the demarcations between and around them. By rejecting the possibility of demonic intervention, Pomponazzi greatly expanded the role of the supposed occult qualities of matter. Such qualities could stimulate thinking about the nature of matter itself, and could subsequently be absorbed into the new natural philosophy. Meanwhile, sceptical philosophers had a new set of arguments for dismissing demons as ineffectual, and ultimately as nothing more than the result of superstitious beliefs.[68]

Another important stimulus towards a new and detailed consideration of occult qualities arose out of university medical faculties. We have already noted that developments in botany and other subjects affiliated to the production of *materia medica* resulted in increased numbers of new drugs being designated as "occult" in their operation, because their efficacy did not depend upon their effects upon the manifest qualities of the patients' humours. This coincided with awareness of the need for reform of medical theory from another quarter. The increased prevalence of pestilential diseases in a Europe where bubonic plague was endemic and where syphilis was cutting a swathe through all classes of society presented problems for traditional medical theory. It was difficult to understand how a theory of disease based on individualistic humoural physiology could account for infectious plagues. Epidemic pestilences strongly suggest, contrary to ancient authority, that diseases have a kind of life of their own; they are real, distinct entities, which can pass from one person to another, or can simultaneously attack great numbers of people irrespective of their individual temperaments. A new understanding of the nature of diseases demands new ways of dealing with them, and the sixteenth century saw three major attempts to reform medical theory. The three would-be reformers, Paracelsus, Girolamo Fracastoro and Jean Fernel all drew upon occult traditions in their suggested reforms. Paracelsus looked to alchemy, not just as a way of producing new medicines, but as a way of understanding the nature of the physiology, and the nature of disease. Fracastoro developed the idea of "seeds" of disease, seminal principles capable of growing in the body and disrupting it, while Fernel believed that pestilences acted not on the humours, but on the substantial form of the body, which Fernel called the 'total

substance' of the body, and they did so, not by affecting the manifest qualities but by means of some occult power over the total substance.[69]

The works of Ficino, Pomponazzi, Paracelsus, Fracastoro, and Fernel are, of course, just salient points in a rapidly changing landscape of intellectual discussion. Throughout the sixteenth century the nature and the role of occult qualities become increasingly prominent in natural philosophizing. This was bound to have unfortunate repercussions for traditional Aristotelianism, since, although occult qualities were allowed for in scholasticism, and traditional natural magic throughout the Middle Ages was loosely premised upon Aristotelian assumptions (alchemy, for example, although going far beyond anything to be found in Aristotle's writings still assumed the truth of the four elements and four qualities), in fact there was very little in Aristotle himself about occult qualities.[70] Indeed, it became increasingly obvious during the Renaissance, when Aristotle came to be studied in the original Greek, that the natural magic tradition owed a great deal to medieval and Arabic interpolations, for example, from Thomas Aquinas, Albertus Magnus, Avicenna, and Alkindi.[71] More to the point, the ideal of science in the Aristotelian tradition was based on the form of the logical syllogism (deductive reasoning), but the premises, the starting points upon which the reasoning was based, had to be uncontentious, evident truths to which all could freely assent. Small wonder, therefore, that the main emphasis in natural philosophical argument was on the supposedly *manifest* qualities, which could fulfill the criteria of being undeniable and evident to all.[72] It was one thing, within this system to occasionally have to resort to occult qualities in one's explanations; it was quite another, however, to see occult qualities playing an increasingly prominent role in a widespread range of natural phenomena. There was a real crisis in Aristotelianism, therefore, concerning the very possibility of dealing with *insensible* properties and entities in a philosophy that was supposedly grounded on human sensation. When writers like Pomponazzi, Jean Fernel, and Daniel Sennert can be seen to be elevating the role of occult qualities in Aristotelianism it seems legitimate to ask whether they are best seen as eclectic Aristotelians or as contributors to the demise of Aristotelianism. Whatever the truth of that, we cannot help but conclude, I think, that Renaissance developments in the notion of occult qualities resulted in a major re-arrangement, in which these qualities came to play a much greater role in reformed versions of natural philosophy, and eventually became absorbed into the mainstream of the new philosophies which completely displaced Aristotelianism.[73]

Finally, unlikely as it may seem to us (or to those of us who remain, like David Brewster, recalcitrant in their belief that all magic was merely the production of knaves and fools), there is every reason to suppose that, as far as Renaissance thinkers were concerned, the occult sciences were the most likely source for the reform of natural philosophy, and for the establishment of a true understanding of God's Creation. Indeed, to a large extent they were the *only* alternative sources of natural knowledge. Although occult qualities were generally assumed to be real, scholastic philosophers were always reluctant to have recourse to them; accordingly, these underexploited occult qualities seemed to offer the most likely source of help for would-be reformers of an increasingly moribund Aristotelian natural philosophy. When the Aristotelian theory of substantial forms, and the associated hylomorphic matter theory began increasingly to seem inadequate, natural philosophers turned to alchemy as a likely pointer to alternative ways of understanding the relationship between bodies and their properties.[74] When Galenic medical theory, which relied almost exclusively on the balance (or imbalance) of the four qualities in the body for understanding disease and treating it, came to be seen as increasingly inadequate,

medical reformers like Fernel, Fracastoro, and the Paracelsians, all turned in one way or another to occult qualities as an alternative.[75] Similarly, every one of the Renaissance thinkers who tried to develop new systems of philosophy, intended to completely replace Aristotelianism, relied to a large extent on aspects of the magical tradition. So much so, in fact, that each of these system-builders, can be seen as contributors themselves to the magical tradition.[76]

This situation, in which would-be reformers of natural philosophy turned to the occult tradition as the most likely way out of all difficulties, continued even late into the seventeenth century, to the period seen as witnessing the dramatic decline of magic. Robert Boyle, recognizing the inadequacy of strict versions of the mechanical philosophy, including Cartesian claims that there were no new motions generated in nature, only transfers of motion from one part of the system to another via collisions, turned once again, as the opponents of Aristotelianism had before him, to alchemy. Newton, recognizing the absurdity of Cartesian vortex theory as an explanation for planetary movements and for gravity, preferred to rely instead upon the assumption that bodies could attract one another across vast distances of empty space.[77]

The example set by Newton makes it hard to deny that, if reformers of natural philosophy believed the occult sciences offered the most likely source for a viable alternative to Aristotelianism, they were right. Descartes was proud of the fact that he had eschewed all occult qualities from his system, and so in a sense believed he had succeeded where Aristotelianism had failed (since it had never quite managed to dispose of occult qualities). But for many, the Cartesian system could be seen to be ultimately unworkable, and rather than eschewing occult qualities, they embraced them as the only realistic alternative.[78] In so doing, occult qualities became absorbed into mainstream reformed natural philosophy. The triumph of Newtonianism, then, with its basic premise that all phenomena could be explained in terms of attractive and repulsive particles capable of acting at a distance, showed not only that Newton was right, but that earlier would-be reformers of natural philosophy who had tried to draw upon the magical tradition were not too far wrong.

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[*] This paper is derived from a much longer paper, which includes fuller substantiation of the points raised: "The Fragmentation of Renaissance Occultism and the Decline of Magic", *History of Science*, 46 (2008), 1-48.

[1] B. J. T. Dobbs, *The foundations of Newton's alchemy* (Cambridge, 1975); idem, *The Janus faces of genius: The role of alchemy in Newton's thought* (Cambridge, 1991).

[2] A. Janiak, *Newton as philosopher* (Cambridge, 2008); S. Ducheyne, *The Main Business of Natural Philosophy: Isaac Newton's Natural-Philosophical Methodology* (Dordrecht, 2012), H. Kochiras, "Gravity and Newton's substance-counting problem", *Studies in History and Philosophy of Science*, 40 (2009), 267-280.

[3] J. Henry, "Gravity and *De gravitatione*: The development of Newton's Ideas on action at a distance", *Studies in History and Philosophy of Science*, 42 (2011), 11-27.

[4] R. E. Schofield, *Mechanism and materialism* (Princeton, 1970); A. Thackray, *Atoms and powers* (Cambridge, MA, 1970).

[5] J. S. Mill, *Collected Works*, ed. J. M. Robson (Toronto, 1974), vol. VIII, 754.

[6] J. M. Keynes, "Newton, the man", in The Royal Society, *Newton tercentenary celebrations* (Cambridge, 1947), 27-34.

[7] P. Rossi, *Francis Bacon: From magic to science* (London, 1968); C. Webster, *From Paracelsus to Newton: Magic and the making of modern science* (Cambridge, 1982); J. Henry, *The Scientific Revolution and the Origins of Modern Science* (Basingstoke, 2008).

[8] B. T. Moran, *Distilling knowledge: Alchemy, chemistry, and the Scientific Revolution* (Cambridge, MA, 2005), 1-7 and 185-9; W. R. Newman, *Atoms and alchemy: Chymistry and the experimental origins of the Scientific Revolution* (Chicago, 2006), 1-20 and 224-5.

[9] For example, P. Casini, "Newton, a sceptical alchemist?"; and A. R. Hall, "Magic, metaphysics and mysticism in the Scientific Revolution", both in M. L. Rhigini Bonelli and W. R. Shea (eds), *Reason, experiment, and mysticism in the Scientific Revolution* (London, 1975), 233-8, and 275-82, respectively.
[10] D. Brewster, *Memoirs of the life, writings and discoveries of Sir Isaac Newton*, 2 vols (Edinburgh, 1855), ii, 374-5.
[11] K. Thomas, *Religion and the decline of magic* (London, 1971). On the continued fortune of magic in popular culture see, for example, R. Muchembled, *Popular culture and elite culture in France, 1400-1750* (Baton Rouge and London, 1985); and O. Davies, *Cunning folk: Popular magic in English history* (New York and London, 2003).
[12] See, T. F. Gieryn, "Boundary-work and the demarcation of science from non-science: Strains and interests in professional ideologies of scientists", *American sociological review*, 48 (1983), 781-95; and B. Barnes, D. Bloor and J. Henry, *Scientific knowledge: A sociological analysis* (London and Chicago, 1996), 140-68.
[13] I am encouraged by the similar claim made brilliantly with regard to alchemy in L. M. Principe and W. R. Newman, "Some problems with the historiography of alchemy", in W. R. Newman and A. Grafton (eds), *Secrets of nature: Astrology and alchemy in early modern Europe* (Cambridge, MA, 2001), 385-431.
[14] S. Clark, "The scientific status of demonology", in B. Vickers (ed.), *Occult and scientific mentalities in the Renaissance* (Cambridge, 1986), 351-74; idem, *Thinking with demons: The idea of witchcraft in early modern Europe* (Oxford, 1997), 161-79.
[15] G. B. della Porta, *Natural magick… in twenty books* (London, 1658), Bk I, Ch. 2, p. 2.
[16] C. Agrippa, *De incertitudine et vanitate omnium scientiarum et artium* (place not given, 1531), chapter 42.
[17] F. Bacon, *Novum organum*, Pt I, Aphorism IV. On magic in the work of Bacon see Rossi, *Francis Bacon* (n. 7); and J. Henry, *Knowledge is power: Francis Bacon and the method of science* (Cambridge, 2002), 42-81.
[18] R. Hooke, *Micrographia* (London, 1665), 12, 15, 16, etc.; I. Newton, Letter to R. Boyle, February 28, 1679, in I. B. Cohen (ed.), *Isaac Newton's papers and letters on natural philosophy* (Cambridge, 1958), 251. See J. Henry, "Robert Hooke, the incongruous mechanist", in M. Hunter and S. Schaffer (eds), *Robert Hooke: New studies* (Woodbridge, 1989), 149-80.
[19] Agrippa, *De incertitudine & vanitate… scientiarum* (n. 16), chapter 42. See also Lauren Kassell, "'All was that land full fill'd of faerie', or magic and the past in early modern England", *Journal of the History of Ideas*, 67 (2006), 107-22.
[20] W. Eamon, *Science and the secrets of nature* (Princeton, 1994); and B. Hansen, "Science and magic", in D. C. Lindberg (ed.), *Science in the middle ages* (Chicago, 1975), 483-506.
[21] See K. Wellman, "Talismans, incubi, divination and the Book of M*: The Bureau d'Adresse confronts the occult", in A. G. Debus and M. T. Walton (eds), *Reading the book of nature: The other side of the Scientific Revolution* (St Louis, 1998), 215-38.
[22] B. Copenhaver, "Did science have a Renaissance?" *Isis*, 83 (1992), 387-407; E. M. W. Tillyard, *The Elizabethan world picture* (London, 1943).
[23] Clark, "Scientific status of demonology" (n. 14); and idem, *Thinking with demons* (n. 14), 161-78.
[24] J. Cotta, *The triall of witch-craft* (London, 1616), 34.
[25] W. Perkins, *Discourse of the damned art of witch-craft* (Cambridge, 1610), 59.
[26] Perkins, *Discourse of the damned art of witch-craft* (n. 25), 20.
[27] Agrippa, *De incertitudine et vanitate… scientiarum* (n. 16), chapter 42.
[28] F. Giuntini, *Speculum astronomiae* (Paris, 1573), quoted from Lynn Thorndike, *A History of Magic and Experimental Science*, 8 vols (New York, 1923-58), vi, 132.
[29] See D. P. Walker, *Spiritual and demonic magic from Ficino to Campanella* (London, 1958), 36, 83; Hansen, "Science and magic" (n. 20), 488-89. As in so many other cases, the Church's attitude forged popular consciousness.
[30] Or some who were more than one of these things. John Napier, for example, inventor of logarithms, also devoted much of his time to alchemy, and was known locally, in Edinburgh, as a wizard. See F. Shennan, *Flesh and bones: The life, passions and legacies of John Napier* (Edinburgh, 1989).
[31] A. G. Molland, "Roger Bacon as magician", *Traditio*, 30 (1974), 445-60, p. 459-60. Consider also the revealingly contradictory title of Bacon's *Epistola de secretis operibus artis et naturae, et de nullitate magiae*, written between 1248 and 1267.
[32] For a recent discussion of Naudé's book see Kassell (n. 19). Molland, "Roger Bacon as magician" (n. 31), 448.

[33] R. Hooke, "Of Dr Dee's book of spirits" (1690), in R. Waller (ed.), *The posthumous works of Robert Hooke* (London, 1705), 203-10. See, Henry, "Robert Hooke" (n. 18), 176-8; R. Deacon, *John Dee, scientist, geographer, astrologer and secret agent to Elizabeth I* (London, 1968). Dee's séances with angels had been published in 1659: *A true & faithful relation of what passed for many yeers between dr. John Dee ... and some spirits*, edited by M. Casuabon (London, 1659). See D. E. Harkness, *John Dee's conversations with angels* (Cambridge: Cambridge University Press, 1999). On Trithemius, see K. Arnold, *Johannes Trithemius (1462-1516)* (Würtzburg, 1971), and W. Shumaker, *Renaissance curiosa* (Binghampton, 1982).
[34] On Bacon's criticisms of magic see Rossi, *Francis Bacon* (n. 7), 31-5.
[35] The retraction appeared in a general attack on all human knowledge, and an affirmation of Christian fideism, C. Agrippa, *De incertitudine & vanitate… scientiarum* (n. 16), but has been shown to share the same magico-religious foundations as the *De occulta philosophia*—so much so that the two works are said to share a basic unity. See M. H. Keefer, "Agrippa's dilemma: Hermetic rebirth and the ambivalence of *De vanitate* and *De occulta philosophia*", *Renaissance quarterly*, 41 (1988), 614-53.
[36] On increasing rejection of sorcery consider M. Hunter, "Witchcraft and the decline of belief", *Eighteenth-century life*, xxii (1998), 139-47.
[37] See B. Vickers, "Introduction", in idem (ed.), *Occult and Scientific Mentalities* (n. 14), 1-55.
[38] F. L. Borchardt, "The Magus as Renaissance man", *Sixteenth century journal*, 21 (1990), 57-76, pp. 59, 72.
[39] On the "scholar and craftsman thesis", see E. Zilsel, *The social origins of modern science* (Dordrecht, 2000); and P. H. Smith, *The body of the artisan: Art and experience in the Scientific Revolution* (Chicago, 2004).
[40] F. Watson, *Vives: On education* (Cambridge, 1913), 209. On Vives, see C. G. Noreña, *Juan Luis Vives* (The Hague, 1970). F. Bacon, *Novum organum* (London, 1620), Part II, Aphorism 31.
[41] On Gilbert, see J. Henry, "Animism and empiricism: Copernican physics and the origins of William Gilbert's experimental method", *Journal of the history of ideas*, 62 (2001), 99-119; on Boyle, see L. Principe, *The aspiring adept: Robert Boyle and his alchemical quest* (Princeton, 1998); and Newman, *Atoms and alchemy* (n. 8).
[42] A. C. Clarke, *Profiles of the future* (London, 1962).
[43] Salluste du Bartas, *His divine weekes and workes*, trans. by J. Sylvester (London, 1606), 221; quoted from J. P. Zetterberg, "The mistaking of 'the mathematicks' for magic in Tudor and Stuart England", *Sixteenth Century Journal*, 11 (1980), 83-97, p. 93.
[44] See, Thorndike, *History of magic and experimental science* (n. 28); M. Sherwood, "Magic and mechanics in medieval fiction", *Studies in philology*, 41 (1947), 567-92; Zetterberg, "The mistaking of 'the mathematicks' for magic" (n. 43); W. Eamon, "Technology as magic in the late middle ages and the Renaissance", *Janus*, (1983), 171-212; G. Molland, "Cornelius Agrippa's mathematical magic", in C. Hay (ed.), *Mathematics from manuscript to print* (Oxford, 1988), 209-19.
[45] See, for example, P. L. Rose, *The Italian Renaissance of mathematics* (Geneva, 1975); R. S. Westman, "The astronomer's role in the sixteenth century: A preliminary survey", *History of science*, 18 (1980), 105-47; N. Jardine, "Epistemology of the sciences", in C. B. Schmitt and Q. Skinner (eds), *The Cambridge history of Renaissance philosophy* (Cambridge, 1988), 685-711; M. Biagioli, "The Social Status of Italian Mathematicians, 1450-1600", *History of science*, 27 (1989), 41-95; P. Dear, *Discipline and experience: The mathematical way in the Scientific Revolution* (Chicago, 1995).
[46] Zetterberg, "The mistaking of 'the mathematicks' for magic" (n. 43).
[47] On Napier, see Shennan, *Flesh and bones* (n. 30). Napier's alchemy remains largely unstudied, but see J. Small, "Sketches of later Scottish alchemists…", *Proceedings of the Society of Antiquaries of Scotland*, 11 (1874–6), 410–38. Literature on Dee is extensive. See S. Clucas, "Recent Works on John Dee (1988-2005): A Select Bibliography", in idem (ed.), *John Dee: Interdisciplinary Studies in English Renaissance Thought* (Dordrecht, 2006), 345-50. The best single study is N. H. Clulee, *John Dee's natural philosophy: Between science and religion* (London and New York, 1988).
[48] John Wilkins, *Mathematical magick, or, the wonders that may be performed by mechanical geometry* (London, 1648). The major study is still B. Shapiro, *John Wilkins: An intellectual biography* (Berkeley, 1969), but see also, A. M. Alfonso-Goldfarb, "An 'older' view about matter in John Wilkins' 'modern' mathematical magick", in A. G. Debus and M. T. Walton (eds), *Reading the book of nature* (n. 21), 133-46.
[49] R. Descartes, *Principia philosophiae* (Amsterdam, 1644), IV, §203. On the impact of the pseudo-Aristotelian *Quaestiones mechanicae*, see H. Hattab, "From mechanics to mechanism: The *Quaestiones mechanicae* and Descartes' physics", in P. R. Anstey and J. A. Schuster (eds), *The science of nature in the seventeenth century* (Dordrecht, 2005), 99-129.

[50] Principe and Newman, "Some problems with the historiography of alchemy" (n. 13). See also, L. M. Principe, "Reflections on Newton's alchemy in light of the new historiography of alchemy", in J. E. Force and S. Hutton (eds), *Newton and Newtonianism* (Dordrecht, 2004), 205-19.
[51] Principe and Newman, "Some problems with the historiography of alchemy" (n. 13), 386. See also W. R. Newman and L. M. Principe, "Alchemy vs. chemistry: The etymological origins of a historiographic mistake", *Early science and medicine*, 3 (1998), 32-65.
[52] Principe and Newman "Some problems with the historiography of alchemy" (n. 13), 418.
[53] Ibid., 413-5. The principle contributor to this new scholarship is Newman himself. See, for a recent example, Newman, *Atoms and alchemy* (n. 8).
[54] W. B. Ashworth jr., "Natural history and the emblematic world view", in D. C. Lindberg and R. S. Westman (eds), *Reappraisals of the Scientific Revolution* (Cambridge, 1980), 303-32.
[55] On these new occultist developments in medicine see J. Henry and J. M. Forrester, "Jean Fernel and the importance of his *De abditis rerum causis*", in idem, *Jean Fernel's On the hidden causes of things: Forms, souls and occult diseases in Renaissance medicine* (Leiden, 2005), 37-44.
[56] It is like comparing Wilkins, *Mathematical magick* (n. 48), with, say, Petrus Severinus, *Idea medicinae philosophicae* (Basle, 1571).
[57] See Robert S. Westman, "Nature, art, and psyche: Jung, Pauli, and the Kepler–Fludd polemic"; and J. V. Field, "Kepler's rejection of numerology", both in Vickers (ed.), *Occult and scientific mentalities* (n. 14), 177–229, and 273–96, respectively; and J. E. McGuire and P. M. Rattansi, "Newton and the 'Pipes of Pan'", *Notes and records of the Royal Society of London*, 21 (1966), 108–43.
[58] The main support for the claim that experimentalism and the utilitarianism of the new philosophies derives from the occult tradition is to be found in Francis Bacon. See Rossi, *Francis Bacon* (n. 7); Henry, *Knowledge is power* (n. 17). See also, for example, J. Henry, "Occult Qualities and the Experimental Philosophy: Active Principles in pre-Newtonian Matter Theory", *History of Science*, 24 (1986), 335-81, idem, "Animism and empiricism" (n. 41); and idem, "The Origins of the Experimental Method—Mathematics or Magic?" in H. Busche, S. Heßbrüggen-Walter (eds), *Departure for Modern Europe: Philosophy between 1400 and 1700* (Hamburg: Felix Meiner, 2011), 702-14.
[59] On the decline of belief in symbolic magic see B. Vickers, "Analogy versus identity: The rejection of occult symbolism, 1580-1680, in idem (ed.), *Occult and scientific mentalities* (n. 14); and idem, "Critical reactions to the occult sciences during the Renaissance", in E. Ullmann-Margalit (ed.), *The scientific enterprise* (Dordrecht, 1992), 43–92, pp. 77–79. See also, B. Copenhaver, "The occultist tradition and its critics", in D. Garber and M. Ayers (eds), *The Cambridge history of seventeenth-century philosophy* (Cambridge, 1998), 454-512.
[60] D. P. Walker, *Spiritual and demonic magic* (n. 29), 84; Thomas, *Religion and the decline of magic* (n. 11); and S. Clark, "The rational witchfinder: Conscience, demonological naturalism and popular superstitions", in S. Pumfrey, P. Rossi, and M. Slawinski (eds), *Science, culture and popular belief in Renaissance Europe* (Manchester,1991), 222–48.
[61] The literature here is vast but an obvious starting point is Thomas, *Religion and the decline of magic* (n. 11). Consider also, Clark, *Thinking with demons* (n. 14). On the socio-political dimensions of alchemy, which has been well served in the literature, see for example, P. M. Rattansi, "Paracelsus and the Puritan revolution", *Ambix*, 11 (1963), 24-32; H. Trevor-Roper, "The Paracelsian movement", in idem, *Renaissance essays* (London, 1985), 149-99; J. A. Mendelsohn, "Alchemy and politics in England", *Past and present*, 135 (1992), 30-78; and W. Newman, "From alchemy to 'chymistry'", in K. Park and L. Daston (eds), *The Cambridge history of science. Volume* 3*: Early Modern Science* (Cambridge, 2006), 497-517. See also, for another example, P. Zambelli, "Magic and radical reformation in Agrippa of Nettesheim", *Journal of the Warburg and Courtauld Institutes*, 39 (1976), 69-103.
[62] For example, T. Digges, *A perfit description of the caelestiall orbes, according to the most auncient doctrine of the Pythagoreans* (London, 1576). See C. B. Schmitt, "*Prisca theologia* e *philosophia perennis*: due temi del Rinascimento italiano e la loro fortuna", in *Atti del V Convegno internazionale del Centro di Studi Umanistici: Il pensiero italiano del Rinascimento e il tempo nostro* (Florence, 1970), 211-36; and D. P. Walker, *The ancient theology* (London, 1972).
[63] *De vita coelitus comparanda* was the third part of Ficino's *De vita triplici* (Florence, 1489). See Walker, *Spiritual and demonic magic* (n. 29), 58.
[64] See, E. Garin, "The philosopher and the magus", in idem (ed.), *Renaissance characters*, translated by L. G. Cochrane (Chicago, 1997), 123-53. See also, Borchardt, "The magus as Renaissance man" (n. 38). We should also remember, however, that even a highly learned magician such as Agrippa might call himself a magus and at the same time be anxious about the religious implications of being a magus. See Keefer, "Agrippa's dilemma" (n. 35).

[65] The most convenient source on the religious *Corpus Hermeticum*, which includes an invaluable introduction, is B. Copenhaver, *Hermetica: The Greek Corpus Hermeticum and the Latin Asclepius* (Cambridge, 1991). On the so-called "technical" writings see A.-J. Festugière, *La révélation d'Hermès Trismégiste*, Vol. 1: *L'Astrologie et les sciences occultes* (Paris, 1950). For brief assessments of the historical significance of the Hermetic writings see B. Copenhaver, "Astrology and magic", in Schmitt and Skinner (eds), *The Cambridge history of Renaissance philosophy* (n. 45), 264–300; idem, "Natural magic, Hermetism, and occultism in early modern science", in D. C. Lindberg and R. S. Westman (eds), *Reappraisals of the Scientific Revolution* (Cambridge, 1990), 261–302; and idem, "Magic", in Park and Daston, *Cambridge history of science. Volume 3* (n. 61), 518-40.
[66] Copenhaver, "Astrology and magic" (n. 65); idem, "Did science have a Renaissance?" (n. 22); Walker, *Spiritual and demonic magic* (n. 29).
[67] Copenhaver, "Astrology and magic" (n. 65), 273.
[68] For an important study of the role of discussions of natural powers and the abilities of demons see W. R. Newman, *Promethean ambitions: Alchemy and the quest to perfect nature* (Chicago, 2004).
[69] On Paracelsus see, for example, W. Pagel, *Paracelsus: An introduction to philosophical medicine in the era of the Renaissance* (Basle, 1958); A. Weeks, *Paracelsus: Speculative theory and the crisis of the early Reformation* (Albany, 1997). On Fracastoro, see V. Nutton, "The seeds of disease: An explanation of contagion and infection from the Greeks to the Renaissance." *Medical History,* 27 (1983), 1-34; and idem, "The reception of Fracastoro's theory of contagion: The seed that fell among thorns?" *Osiris*, Second Series, 6 (1990), 196-234. On Fernel, see Henry and Forrester, "Jean Fernel and the importance of his *De abditis rerum causis*" (n. 55).
[70] For brief accounts of the nature of alchemy see B. T. Moran, *Distilling knowledge* (n. 8); Newman, *Atoms and alchemy* (n. 8); and idem, "From alchemy to 'chymistry'" (n. 61). On occult qualities see K. Hutchison, "What happened to occult qualities in the Renaissance?" *Isis*, 73 (1982), 233-53; and R. Millen, "The manifestation of occult qualities in the Scientific Revolution", in M. J. Osler and P. L. Farber (eds), *Religion, science and worldview* (Cambridge, 1985), 185–216; and Henry "Occult qualities" (n. 58).
[71] Copenhaver, "Astrology and Magic" (n. 65).
[72] On this aspect of Aristotelianism see, for example, P. Dear, *Discipline and experience* (n. 45), 11-31; and idem, "The meanings of experience", in Park and Daston (eds), *Cambridge history of science. Volume 3* (n. 61), 106-31
[73] On Pomponazzi see, Walker, *Spiritual and demonic magic* (n. 29), 107-11. On Fernel: Henry and Forrester, "Jean Fernel and the importance of his *De abditis rerum causis*" (n. 55). On Sennert, see Newman, *Atoms and alchemy* (n. 8). For general studies of this theme see Millen, "Manifestation of occult qualities" (n. 70); and Henry, "The Origins of the Experimental Method" (n. 58).
[74] Both D. Garber and L. S. Joy acknowledge the role of chemical ideas in early modern changes in natural philosophy. See D. Garber, "Physics and foundations", and L. S. Joy, "Scientific explanation from formal causes to laws of nature", both in Park and Daston (eds), *Cambridge history of science. Volume 3* (n. 61), 29-33, and 70-105, respectively.
[75] See Henry and Forrester, "Jean Fernel and the importance of his *De abditis rerum causis*" (n. 55); S. Matton, "Fernel et les alchimistes", *Corpus*, 41 (2002), 135-97; Nutton, "The seeds of disease" (n. 69); and idem, "The reception of Fracastoro's theory of contagion" (n. 69). As representative of the Paracelsians, consider Severinus: Jole Shackelford, *A philosophical path for Paracelsian medicine: The ideas, intellectual context, and influence of Petrus Severinus (1540/2-1602)* (Copenhagen, 2004).
[76] Henry, "The Origins of the Experimental Method" (n. 58).
[77] Henry, "Gravity and *De gravitatione*" (n. 3).
[78] Henry, "Occult qualities" (n. 58).